# Leveraging AI for Effective Teaching: A Machine Learning Approach to Tandem Learning in Mathematics

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## Declaration of Competing Interest

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## Ethical approval

Ethical consent was deemed unnecessary by the authors and the educational institution; however, written consent was still obtained from all participants.

## Author contributions

All authors contributed to the study’s conception and design. Material preparation, data collection, and analysis were performed by Bor Bregant, Darjo Felda, and Daniel Doz. The first draft of the manuscript was written by Bor Bregant and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

## Data availability statement

The authors declare that the data supporting the findings of this study are publicly available. Dataset used is available at

<https://github.com/borbregant/ai_tandem_learning/blob/main/data_cleaned.xlsx>. Machine learning code is available at

<https://github.com/borbregant/ai_tandem_learning/blob/main/analiza_test.ipynb>. t-SNE visualization code is available at

https://github.com/borbregant/ai\_tandem\_learning/blob/main/t-SNE.ipynb.

## Abstract

Educational institutions aim to offer quality education, employing diverse teaching methods like tandem learning. Recognizing the need for personalized approaches, institutions should use data mining techniques to extract insights from educational datasets for optimal predictive model selection for individual students or classrooms. This study evaluated machine learning (ML) algorithms for predicting student responses to tandem learning.

A dataset of 89 high school students and 13 predictors was used, focusing on a three-state outcome representing positive response to tandem learning. The predictor variables included gender, class, teacher, previous mathematics grade, MBTI variables (extroversion-introversion, sensing-intuition, thinking-feeling, and judging-perceiving), mathematical anxiety, mathematical motivation, qualitative interaction in tandem learning, quantitative interaction in tandem learning, and whether the student outperformed their partner in tandem learning. Nine classification ML algorithms were implemented, and the 5×2-fold stratified cross-validation was applied.

Using all predictor variables, Random Forest and K-Nearest Neighbors performed the best, having accuracies of 0.55, and 0.53, and macro F1 scores 0.37, and 0.36 respectively, which is fair considering data balance. Balancing the dataset and using only 2 outcome classes, the performance improved, with the best algorithm being Gradient boosting, performing moderately well (accuracy = 0.59; F1-score = 0.59).

Results suggest that ML algorithms struggle to predict student responses to group learning in mathematics with the current variables and sample size. Thus, they may not yet aid teachers in selecting teaching methods effectively. However, simplifying the classification from three states to two improved outcomes, indicating that a less complex approach can yield more reliable predictions.

### Keywords

Assessment, mathematics education, machine learning, tandem learning, teaching methods

### Math subject classification, MSC2020

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